- Contaminant concentrations were generally higher in samples collected from onsite catch basins compared to right-of-way samples. For example, BEHP concentrations in most of the right-of-way samples ranged from about 15-300 mg/kg OC compared to 12-1,000 mg/kg OC in the onsite samples. As shown in Table 12, exceedances of sediment management standards for metals were also more frequent in the onsite samples.

Table 12. Summary of exceedances of sediment management standards for metals in storm drain sediment samples.

Metal	Onsite catch basins	Right-of-way catch basins	Sediment traps
Copper	9%	0%	0%
Lead	18%	10%	0%
Mercury	21%	3%	0%
Zinc	68%	29%	40%

- None of the sediment samples collected from onsite and right-of-way catch basin samples and inline sediment traps exceeded the sediment management standards for PCBs and PAHs. Therefore, it is unlikely that these chemicals will be a problem in waterway sediment following cleanup.
- BEHP poses the most serious concern for recontamination in waterway sediment after cleanup. Concentrations frequently exceeded the sediment management standards in all of the samples collected (82 percent, 65 percent, and 80 percent in the onsite catch basins, right-of-way catch basins, and inline sediment traps, respectively.

Phthalate Source Study

Phthalates, particularly bis(2-ethylhexyl)phthalate (BEHP), are contaminants of concern in the majority of the early action sites in the Lower Duwamish Waterway. Because they are a regional concern extending beyond the Duwamish Waterway, King County and SPU joined with the City of Tacoma to conduct joint testing of various products and materials to help identify the source of these chemicals. The City of Tacoma had previously submitted a sampling and analysis plan for product testing to the U.S. Environmental Protection Agency (EPA) as part of the Thea Foss Superfund investigation (Tacoma 2003). To benefit from the additional resources afforded by participation of the King County Environmental Laboratory, the joint task force added other materials for testing beyond those cited in the original plan.

The intent is to use this information about the phthalate content of common consumer products in conjunction with the source tracing efforts to identify specific sources of phthalates to the storm drains and the sanitary sewer. In addition, project staff hoped to identify specific products low in phthalates that they could recommend as replacement products to businesses and residents.

Background

Phthalates are a class of industrial compounds commonly used as softeners in plastics, as solvents, as oil in vacuum pumps and electric capacitors and transformers, and as carriers for fragrances and pesticides. They have also been reported in personal care products (Houlihan et.

al., 2002). Bis(2-ethylhexyl)phthalate (BEHP) is the most prevalent phthalate in the Duwamish sediments, and is a contaminant of concern at the majority of the early action sites, including the Duwamish Diagonal site. Butyl benzyl phthalate is also a contaminant of concern at this site.

BEHP is the most frequently detected phthalate in stormwater and catch basin samples (USEPA 1983; Herrera 1998; Tacoma 1990; Tacoma 1999; Tacoma 2002). However, until recently, phthalates have not been the focus of source control efforts, primarily because phthalates, particularly BEHP have long been considered a laboratory contaminant. As a result, information on the particular types of businesses that discharge BEHP is scarce, as is information on the type of products that contain substantial amounts of BEHP. To assist in identifying sources of BEHP and other phthalates staff at King County and Seattle Public Utilities joined with staff from the City of Tacoma to test a variety of products and materials.

Products Tested

Prior to selecting the additional materials, project staff reviewed available literature on phthalate sources, talked with representatives from a number of agencies, and reviewed data from EPA (TRI Explorer database) and the Washington State Department of Ecology (Toxic Release Inventory Information Display System or TRIIDS). The review indicated that phthalates are a component of many consumer products and therefore could be a significant non-point source to the waterway.

The additional products selected for testing include those that are commonly used in either Tacoma's Thea Foss Waterway and/or the Lower Duwamish Waterway and that literature reviews suggested might be high in phthalates. Testing focused on products that have not been analyzed for phthalate content. Products such as cosmetics that have already been analyzed were not tested. The goal was to analyze at least three brands or samples for each product type. Products tested by each lab are listed in Table 13.

Table 13. Products tested.

King County Environmental Lab	Tacoma Laboratory
Carwash soap (and liquid wax)	Atmospheric dust
Windshield washer fluid (and defoggers)	Tires
Dish soap (commercial and household)	Cigarette butts
Boat effluents (graywater or bilge)	Break pad dust
Oils (new and used)	Plastic bottles
Armor All (or equivalent)	Vehicle undercoating
Tire dressing (cleaner)	Asphalt binder
Inks and dyes (including printing inks)	Roofing tar
Asphalt sealer	Plastic wrap/packaging peanuts

Methods

The focus on the study was on BEHP, one of the contaminants of concern in the Lower Duwamish Superfund Site. However, other phthalates were also analyzed, as were polynuclear aromatic hydrocarbons (PAHs).

The source study materials and overall approach were presented previously to the EPA in a sample and analysis plan prepared by the City of Tacoma (2003). The joint task force has added additional materials to test above those cited in the plan to account for the different sewerage/stormwater conveyance systems and industry base of the Duwamish Waterway basin versus the Thea Foss Waterway basin.

Both King County and Tacoma laboratories used EPA Method 8270C (GC/MS) to analyze product materials. Because the focus of the testing was on identifying products high in phthalates, the target detection limits for the analysis was set at 1 to 10 ppm (1-10 mg/L in liquid products and 1-10 mg/kg in solid products). The laboratories adhered to standard EPA protocols as much as possible, which included implementing standard quality assurance practices such as analysis of method blanks, spikes, and surrogates.

The specific target parameters are listed in Table 14.

Table 14. Chemical parameters analyzed in product samples.

Phthalates	PAHs
Benzyl butyl phthalate	2-Methylnaphthalene
Bis(2-ethylhexyl)phthalate	Acenaphthene
Di-*n*-butyl phthalate	Acenaphthylene
Di-*n*-octyl phthalate	Anthracene
Diethyl phthalate	Benzo(*a*)anthracene
Dimethyl phthalate	Benzo(*a*)pyrene
	Benzo(*b*)fluoranthene
	Benzo(*g*,*h*,*i*)perylene
	Benzo(*k*)fluoranthene
	Chrysene
	Dibenzo(*a*,*h*)anthracene
	Fluoranthene
	Fluorene
	Indeno(1,2,3-*cd*)pyrene

The King County Laboratory and the Tacoma Laboratory each analyzed samples from one matrix type. Tacoma tested solids while King County tested liquids. In addition to phthalates and PAHs, the laboratories also recorded the top five most frequently detected tentatively identified compounds (TIC).

The Tacoma laboratory also developed a method to measure atmospheric deposition by analyzing material collected from the roof of the Tacoma Dome. A wetted cotton rag was divided into two portions, one being used for a field blank and the other to wipe the Dome's surface. A 16 square foot area on the northeast section of the Dome was wiped clean using the sampling rag and an analysis was performed on both samples. The sampling procedure was repeated after the Tacoma Dome was cleaned by a professional service to determine whether phthalates were present in the rubberized vinyl roofing material.

Table 15: Duwamish Source Tracing: Liquid product results

All results are in ug/L

	Drinking water through Barista maker		Dishwasher soap, McDonalds		Dish soap, Ultra Joy with aromatic release		Dish soap, Ultra Palmolive (antibacterial)		All purpose Cleaner, Simple Green (concentrated)		Boat tap water		Boat grey water		Tire Dresser Black Magic Tire Wet		Tire Dressing 1		Tire Dressing 2		Automated car wash rinsate from Elephant Car wash	
Phthalates (µg/L)																						
Bis(2-ethylhexyl)phthalate	0.45	U	4,800	U	3,600	U	5,900	U	6,000	U	1.90	U	52		10,000	U	10,000	U	10,000	U	7.98	
Benzyl butyl phthalate	0.29	U	6,000	U	6,000	U	6,000	U	6,000	U	0.31	U	20		30,000	U	30,000	U	30,000	U	0.32	U
Di-n-butyl phthalate	1.88		10,000	U	10,000	U	10,000	U	10,000	U	0.52	U	116		50,000	U	50,000	U	50,000	U	0.53	U
Di-n-octyl phthalate	0.29	U	6,000	U	6,000	U	6,000	U	6,000	U	0.31	U	3.6	U	30,000	U	30,000	U	30,000	U	0.32	U
Diethyl phthalate	1.05		10,000	U	10,000	U	19,000		10,000	U	0.52	U	6.0	U	176,000		700,000		701,000		1.53	
Dimethyl phthalate	0.19	U	4,000	U	40,000	U	4,000	U	4,000	U	0.21	U	2.4	U	20,000	U	20,000	U	20,000	U	0.21	U
PAHs (µg/L)																						
Acenaphthene																						
Acenaphthylene																						
Anthracene																						
Benzo(a)anthracene																						
Benzo(a)pyrene																						
Benzo(b)fluoranthene																						
Benzo(g,h,i)perylene																						
Benzo(k)fluoranthene																						
Chrysene																						
Dibenzo(a,h)anthracene																						
Fluoranthene																						
Fluorene																						
Indeno(1,2,3-cd)pyrene																						
Naphthalene																						
Phenanthrene													4.4									
Pyrene																						

U: The analyte was not detected at or above the reported value

Table 15: Duwamish Source Tracing: Liquid product results

All results are in ug/L

	Car wax/soap, Turtle Wax 2 in 1 Wash Plus Wax	Car care product Armorall Protectant	Car Wash Soap, Mother's California Gold Car Wash	Automated car wash product, Harmony Presoak 180 (elephant wash)	Automated car wash product, Harmony Triple Coat	RainX	Clear Shield Windshield Fluid	Asphalt Sealer	Rainwater exposed to asphalt sealer	Driveway Sealer, Henry 132 Driveway Coating	New Penzoil Oil Synthetic
Phthalates (µg/L)											
Bis(2-ethylhexyl)phthalate	5,100 U	3,900 U	9,600 U	2,000 U	302,000 U	10,000 U	5,100 U	10,000 U	1,200 U	10,000 U	10,000 U
Benzyl butyl phthalate	6,000 U	6,000 U	6,000 U	6,000 U	6,000 U	30,000 U	6,000 U	6,000 U	300 U	6,000 U	30,000 U
Di-n-butyl phthalate	10,000 U	10,000 U	10,000 U	10,000 U	10,000 U	50,000 U	10,000 U	10,000 U	500 U	10,000 U	50,000 U
Di-n-octyl phthalate	6,000 U	6,000 U	6,000 U	6,000 U	6,000 U	30,000 U	6,000 U	6,000 U	300 U	6,000 U	30,000 U
Diethyl phthalate	10,000 U	10,000 U	10,000 U	10,000 U	1,320,000	50,000 U	10,000 U	10,000 U	500 U	10,000 U	50,000 U
Dimethyl phthalate	4,000 U	4,000 U	4,000 U	4,000 U	4,000 U	20,000 U	4,000 U	4,000 U	200 U	4,000 U	20,000 U
PAHs (µg/L)											
Acenaphthene										871,000	
Acenaphthylene											
Anthracene										1,180,000	
Benzo(a)anthracene										1,260,000	
Benzo(a)pyrene										1,320,000	
Benzo(b)fluoranthene										1,500,000	
Benzo(g,h,i)perylene										787,000	
Benzo(k)fluoranthene										508,000	
Chrysene								9,000		1,150,000	
Dibenzo(a,h)anthracene										143,000	
Fluoranthene										5,360,000	
Fluorene										749,000	
Indeno(1,2,3-cd)pyrene										824,000	
Naphthalene								35,400		1,640,000	
Phenanthrene	6,100									5,930,000	
Pyrene										3,490,000	

Table 15: Duwamish Source Tracing: Liquid product results

All results are in ug/L

	Used Penzoil Oil Synthetic	Car Engine Oil Mobil 1 5W-30	Car Engine Oil Valvoline SAE 20W-50	Spent automotive oils	Spent automotive oils	Tristar Extender (ink product)	Polycon Blue Crude M31 (ink product)	Inxvelope Extender (ink product)	Inxvelope dense black (ink product)
Phthalates (µg/L)									
Bis(2-ethylhexyl)phthalate	75,000 <RDL	10,000 U	10,000 U	10,000 U	77,000 <RDL	6,300 U	15,000 U	11,000 U	8,500 U
Benzyl butyl phthalate	581,000	3,390,000	30,000 U	30,000 U	30,000 U	6,000 U	6,000 U	6,000 U	6,000 U
Di-n-butyl phthalate	50,000 U	50,000 U	50,000 U	50,000 U	50,000 U	10,000 U	10,000 U	10,000 U	10,000 U
Di-n-octyl phthalate	30,000 U	30,000 U	30,000 U	30,000 U	30,000 U	6,000 U	6,000 U	6,000 U	6,000 U
Diethyl phthalate	50,000 U	50,000 U	50,000 U	50,000 U	50,000 U	10,000 U	10,000 U	10,000 U	10,000 U
Dimethyl phthalate	20,000 U	20,000 U	20,000 U	20,000 U	20,000 U	4,000 U	4,000 U	4,000 U	4,000 U
PAHs (µg/L)									
Acenaphthene									
Acenaphthylene									
Anthracene	46,000								
Benzo(a)anthracene	98,000				<RDL				
Benzo(a)pyrene									
Benzo(b)fluoranthene									
Benzo(g,h,i)perylene									
Benzo(k)fluoranthene									
Chrysene	65,000								
Dibenzo(a,h)anthracene									
Fluoranthene	56,000				36,000				
Fluorene									
Indeno(1,2,3-cd)pyrene									
Naphthalene	194,000			110,000	357,000				
Phenanthrene	104,000				106,000				
Pyrene	118,000				85,000				21,800

Table 16: Duwamish Source Tracing: Solid product testing results

Results are listed on a dry wt basis

Source	Brake Pad NAPA TS-728A-M	Brake Pad NAPA TS-728A	Tire Dunlop K327MG	Tire Sears Guardsman 4OT/E	Tire Goodyear Integrity	MOPAR brake pad, used	Motorcraft brake pad, new	Used Car brake pad dust	Used Car brake pad-Auto	Ford-Motorcraft Serp Belt- used	MOPAR Serp Belt- used
Phthalates in ug/kg											
Bis(2-ethylhexyl)phthalate	**170,000** 10X	**33,000**	**12,000**	**47,000**	**5,400**	**1,100**	920 U	**52,000**	4,000 U	**900,000** J 20X	**21,000**
Butylbenzylphthalate	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	**1,500**	4,000 U	1,100 U	950 U
Di-n-butylphthalate	**22,000**	**17,000**	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	**1,900**	**950**
Di-n-octyl phthalate	**13,000** J	**12,000** J	4,600 UJ	2,700 UJ	2,800 UJ	830 U	920 U	**1,700**	4,000 U	1,100 UJ	950 UJ
Diethylphthalate	990 U	940 U	4,600 U	2,700 U	2,800 U	**1,800**	**2,000**	910 U	4,000 U	**3,100**	**2,100**
Dimethylphthalate	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
LPAHs in ug/kg											
2-Methylnaphthalene	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Acenaphthene	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Acenaphthylene	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Anthracene	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Fluorene	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Naphthalene	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Phenanthrene	990 U	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	**1,000**	4,000 U	1,100 U	950 U
HPAHs in ug/kg											
Benzo(a)anthracene	990 U	940 U	4,600 U	**12,000**	**9,900**	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Benzo(a)pyrene	990 UJ	940 UJ	**4,600** J	2,700 UJ	2,800 UJ	830 U	920 U	910 U	4,000 U	1,100 UJ	950 UJ
Benzo(g,h,i)perylene	990 UJ	940 UJ	**11,000** J	**3,300** J	2,800 UJ	830 U	920 U	910 U	4,000 U	1,100 UJ	**2,400** J
Benzo(b,k)fluoranthenes	990 UJ	940 UJ	**6,000** J	**3,500** J	2,800 UJ	830 U	920 U	910 U	4,000 U	1,100 UJ	950 UJ
Chrysene	990 UJ	940 U	4,600 U	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Dibenzo(a,h)anthracene	990 UJ	940 U	4,600 UJ	2,700 UJ	2,800 UJ	830 U	920 U	910 U	4,000 U	1,100 UJ	950 UJ
Fluoranthene	990 U	940 U	**12,000**	2,700 U	2,800 U	830 U	920 U	910 U	4,000 U	1,100 U	950 U
Indeno(1,2,3-c,d)pyrene	990 UJ	940 UJ	4,600 UJ	2,700 UJ	2,800 UJ	830 U	920 U	910 U	4,000 U	1,100 UJ	950 UJ
Pyrene	**3,400**	**1,400**	**49,000**	**15,000**	**8,800** P	830 U	920 U	**1,900**	4,000 U	**5,900**	**1,400**

U: The analyte was not detected at or above the reported value
UJ: The analyte was not detected at or above the reported estimated result
J: The analyte was positively identified. The associated value is an estimate
P: The analyte was quantitated based on the Internal Standard Phenanthrene-d10
10X: Indicates the value is based on a 1:10 dilution

Table 16: Duwamish Source Tracing: Solid product testing results

Results are listed on a dry wt basis

Source	Ford-Motorcraft Serp Belt-new	New Cigarette butt Marlbro light 100	Used Cigarette butt- Muni	Used Cigarette butt- TDome	Plastic Bottles - Tacoma Recycling	Packing Peanuts-Tacoma Recycling	Crafco Asphalt Sealer	US Oil Liquid Asphalt-NC800	US Oil Asphalt Cement
Phthalates in ug/kg									
Bis(2-ethylhexyl)phthalate	**3,900**	5,400 U	**67,000** 10x	49,000 U 10x	810 U	**18,000**	16,000 U	19,000 UJ	20,000 UJ
Butylbenzylphthalate	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	**670,000**	16,000 U	19,000 UJ	20,000 UJ
Di-n-butylphthalate	970 U	5,400 U	**200,000** 10x	**210,000** 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
Di-n-octyl phthalate	970 U	5,400 UJ	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 UJ	19,000 UJ	20,000 UJ
Diethylphthalate	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
Dimethylphthalate	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
LPAHs in ug/kg									
2-Methylnaphthalene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	**630,000**	20,000 U
Acenaphthene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
Acenaphthylene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
Anthracene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
Fluorene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	**19,000**	20,000 U
Naphthalene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	**240,000**	20,000 U
Phenanthrene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
HPAHs in ug/kg									
Benzo(a)anthracene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 UJ	20,000 UJ
Benzo(a)pyrene	970 U	5,400 UJ	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 UJ	19,000 UJ	20,000 UJ
Benzo(g,h,i)perylene	970 U	5,400 UJ	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 UJ	**19,000** J	20,000 UJ
Benzo(b,k)fluoranthenes	970 U	5,400 UJ	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 BJ	19,000 UJ	20,000 UJ
Chrysene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	**22,000** J	20,000 UJ
Dibenzo(a,h)anthracene	970 U	5,400 UJ	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 UJ	19,000 UJ	20,000 UJ
Fluoranthene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 U	20,000 U
Indeno(1,2,3-c,d)pyrene	970 U	5,400 UJ	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 UJ	19,000 UJ	20,000 UJ
Pyrene	970 U	5,400 U	49,000 U 10x	49,000 U 10x	810 U	9,500 U	16,000 U	19,000 UP	20,000 UP

U: The analyte was not detected at or above the reported value
UJ: The analyte was not detected at or above the reported estimated result
J: The analyte was positively identified. The associated value is an estimate
P: The analyte was quantitated based on the Internal Standard Phenanthrene-d10
10X: Indicates the value is based on a 1:10 dilution

Results

Both labs have completed an initial round of analyses. Results are presented in Tables 15 and 16. Both solids and liquids analyses presented challenges for the labs. Solids products were shredded and ground prior to extraction. Interference from other organic compounds present in the product matrix created difficulties for the liquid products. Samples were diluted to minimize matrix interferences. However, the additional dilution resulted in samples being flagged because of high levels of phthalates in the blank samples.

Liquid products

As shown in Table 17, BEHP, the primary chemical of concern in waterway sediment was detected above the analytical detection limit in only 4 liquid samples.

Table 17. BEHP detected in liquid product samples.

Product	BEHP (µg/L)
Used oil from commercial lube shop	77,000
Used synthetic oil[a]	75,000
Boat grey water	52
Automated carwash rinsate	8

a. Collected from a single vehicle after 3 months of use. One quart of fresh non-synthetic oil added during the 3-month period.

Table 18 lists the products that also contained higher levels of other phthalates, primarily diethyl phthalate and benzyl butyl phthalate.

Table 18. Other phthalates detected in liquid product samples.

Product	Diethyl Phthalate (µg/L)	Butyl Benzyl Phthalate (µg/L)
Tire dressing	176,000	30,000U
Tire dressing	700,000	30,000U
Tire dressing	701,000	30,000U
Automated car wash product	1,320,000	6,000U
Used synthetic oil	50,000U	581,000
Unused motor oil	50,000U	3,390,000

On an unrelated project, the King County Local Hazardous Waste Program analyzed BEHP concentrations in a variety of cutting oils used at machine shops throughout King County. BEHP concentrations ranged from 1,300 µg/L to 420,000 µg/L.

Solid Products

Solid products contained considerably more phthalates than liquid products. Levels of BEHP were significantly above detection levels in serpentine belts (up to 900,000 µg/kg), used cigarette butts (up to 67,000 µg/kg), packing peanuts (670,000 µg/kg), brake pads (up to 170,000 µg/kg)

and brake pad dust (52,000 µg/kg), and tires (up to 47,000 µg/kg). Results varied between brands of brake pads and tires. BEHP was not present above the analytical detection level in new cigarette butts, plastic bottles, asphalt, or asphalt sealer.

In addition, di-*n*-butylphthalate was found in used cigarette butts (200,000 µg/kg), some brake pads (17,000-22,000 µg/kg), and certain automobile serpentine belts (950-1,900 µg/kg). Di-*n*-butylphthalate was not found in the one new cigarette butt that was tested.

Butyl benzyl phthalate was found in packing peanuts (670,000 µg/kg) and in small amounts in used car brake pad dust (1,500 µg/kg). Diethyl phthalate was found in some brake pads (1,800-2,000 µg/kg) and some serpentine belts (2,100-3,100 µg/kg).

Tacoma Dome sampling

Sampling took place on May 13, 2003 (before cleaning) and July 3, 2003 (after cleaning). The roof wipe samples collected before the Dome roof was cleaned indicated that material deposited on the roof surface contained approximately 600 µg/square foot of BEHP. Samples collect shortly after the roof was cleaned yielded a BEHP concentration of approximately 42 µg/square foot of roof surface, which indicates that about 7 percent of the BEHP in the sample collected before cleaning was contributed from the roof surface rather than atmospheric deposition of phthalates. The Dome surface had last been washed 2 years prior to this sampling event. The rain record indicates that 1.89 inches of rain fell during the prior 30 days to the May sampling and no measurable rain occurred 6 days prior to sampling.

Conclusions

The low or non-detected levels of BEHP in almost all of the cleaning and maintenance products tested indicate that businesses in the Duwamish do not need to make significant changes in the products that they are using for vehicle maintenance/cleaning activities. Results also suggest that we need to look elsewhere for more substantial sources of phthalates. One possible source of some phthalates is cutting oils used at machine shops.

High levels of phthalates, particularly BEHP in brake pads, serpentine belts, and tires indicate that these materials may be a source of phthalates to the waterway via deposition of worn product particles on roadway surfaces and subsequent washoff in stormwater runoff. Automotive sources of BEHP should also be considered given that two of the three used motor oil samples contained significant concentrations of BEHP, but none of the unused/new oil samples contained BEHP above analytical detection limits. The literature review also suggests that some vehicle fuel products, such as diesel, contain BEHP that may be released into the atmosphere in the exhaust (California Air Resources Board, 1997). This theory is supported by results from the sampling of the Tacoma Dome roof. The next step will be to test for the presence of phthalates in the air in the Duwamish basin and to continue with source tracing using sediment traps and catch basin sampling.